

PROGRESS TOWARD CALIBRATION OF THE CLEMENTINE NIR CAMERA DATA SET.

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Included in the results of Clementine's lunar mapping campaign is a 6 band multispectral data set collected by a 256x256 element near-IR camera, known as the "NIR"ⁱ. This camera collected near-global imaging coverage of the Moon at 1.1, 1.25, 1.5, 1.99, 2.6 and 2.7 microns. Utilization of this data set should allow fundamentally new lunar science to be accomplished including mapping pyroxene chemistry, determining olivine abundance with high sensitivity, and identifying areas where OH-bearing minerals, emplaced by comets or other processes, may be found.

This data set has not been widely utilized because the camera suffered from two serious problems inhibiting science applications. First, the preflight calibration of gain and offset states leaves up to 10% residual errors when these values are applied to the data. In other words, two images of the same area obtained with two different gain states will return calibrated values different by up to 10%. Given the subtlety of lunar color, this is a huge error and forbids inter-area comparison.

Second, the camera suffered from a drifting additive offset which differs throughout an orbit and from orbit to orbit. The magnitude of this offset relative to the lunar signal varies from filter to filter but is as much as 100% of the 2.6 micron filter and as little as 10-20 percent of the 1.1 micron filter. The drift has the alarming symptom that calibrated counts derived from observations of space at the beginning and end of each orbit are higher than counts derived from unilluminated portions of the Moon near the poles.

Until recently, it was not clear that the data set could be calibrated at all, but recent work has shown great promise and gives us high hopes that the data set can be recovered. First, the near-final calibration of the UVVIS data set

has provided an important reference against which to measure the evolving NIR data. Our primary reference tool is a global mosaic constructed of the data from the UVVIS 1 micron filter, treating each image as a single pixel and the NIR bands treated in the same manner. In principle there should be a high degree of correlation between the UVVIS 1.0 micron data and the NIR 1.1 micron data and only weak color contrast. In practice, when the data from these two filters are compared the flaws due to the poor gain calibration and offset drift are quite obvious. Fortunately, when each of the two months of the Clementine mission are treated separately, the effects of these two problems are easier to separate. In the first month the offset drift from orbit to orbit was modest, but up to a dozen gain states were employed as the spacecraft engineers attempted to identify optimum camera settings in the face of the offset drift. Thus for data obtained in the first month fixing the gain problem is the challenge. In the second month many fewer gain states were employed but the offset drift was severe. We focus on the second month to address the offset issue.

The gain states employed by the NIR camera were generated using a network of resistors and switches. The number of resistors and switches are far fewer than gain states employed, so in order to solve the gain problem, we have developed a model of the gain network and are attempting to optimize the gain via reasonable adjustment of the resistor values in the network, including the switch resistances. This adjustment is based on the assumption put forward by Travis White and Nowell Sewall of Lawrence Livermore National Laboratory, that the thermal conditions on the spacecraft during the mission were sufficiently different than during ground calibration to affect their values in lunar orbit. The objective function is a difference between the 1.0 micron uvvis mosaic

and the 1.1 NIR mosaic, with a global inter-camera gain and offset floated to minimize the color contrast between highland and mare. Our initial experiments have shown dramatic improvements in gain state boundary errors leading us to believe with high confidence that we can achieve an optimum set of gains.

The offset drift appears to be related to thermal stray light not observed in ground calibration. The NIR camera has a cold cutoff filter which excludes radiation beyond about 2.75 microns from the focal plane array which is sensitive to 5 microns. In the laboratory the camera took 10-15 minutes from turn-on of its mechanical cryocooler to achieve a level and low background level. This performance is also observed in the LWIR camera. However, after launch the NIR camera took over 45 minutes to achieve low and level background during observations of space prior to mapping. This effect was not observed in the LWIR camera. It was hypothesized that the cold filter came partially detached from its cold finger during launch shock. This failure was observed and presumed solved in preflight shake tests. This partial detachment led to poor thermal contact and a long cooling curve on the filter. This explains why observations of space prior to mapping during an orbit show high counts; the filter has not cooled from cryocooler turn-on.

This does not explain why high counts in space are observed following each mapping orbit. However, Travis White of LLNL, mentioned above, suggested that thermal light from the spacecraft may be leaking in through the point of failure of the filter.

This suggestion is supported by a high degree of correlation between our error function for the second month, and the cryocooler temperature as reported in the PDS header of the Clementine data set. The correlation is good, but not quite good enough to allow science applications. We are currently checking all the temperatures on the spacecraft to determine if high correlations can be found. (It should be noted that this drift is not dark current. The FPA temperature was extremely stable throughout the mission). However, these results are highly encouraging and as is the case for the gain problem, we have high hopes that this problem can be resolved.

There are numerous second order problems still to be dealt with such as flat fields, pixel dependencies in the offset error and near-IR phase functions, but we feel these are quite tractable once the Big Two are finally resolved.

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